

## **Aircraft Pilot Assistance System and Method**

### **BACKGROUND OF THE INVENTION**

#### **Field of the Invention**

This invention relates to a recovery system and method for detecting and warning a  
5 pilot of an unsafe attitude of the aircraft and providing voice instructions to help the pilot  
recover the aircraft from a presently or potentially dangerous situation.

Many aircraft accidents caused by pilot error involve the pilot's failure to maintain a  
safe altitude and/or the pilot's spatial disorientation. The pilot may have the aircraft in a  
nose-high attitude which can produce a stall, or in a nose-low attitude which can put it in  
10 a descending spiral. These problems can occur to a VFR (visual flight rules) pilot who  
inadvertently flies into instrument meteorological conditions (IMC), to and IFR  
(instrument flight rules) pilot who is out of practice, or to any pilot who suffers hypoxia,  
fatigue, or another condition that temporarily affects his/her flying ability. To recover the  
aircraft from a dangerous attitude involves procedures which a disoriented pilot may not  
15 have the presence of mind to execute.

In addition, turbulence may cause the aircraft to depart controlled flight, or there may  
be a partial equipment failure of the vacuum system on the aircraft that powers the  
instrument panel on which the pilot relies. Navigation during partial panel failure requires  
additional pilot attention to the aircraft's heading using the demanding technique of  
20 "timed turns." Without a warning system it is difficult for the pilot to identify a partial  
panel failure because the failure typically takes place gradually as the aircraft's gyros  
spin down and destabilize.

Another factor affecting aircraft safety is the particular terrain over which the aircraft is flying and obstacles which project up from the ground and thus determine the minimum safe altitude (MSA) for flight.

In the United States the altitude determination problem has been alleviated by the  
5 Global Positioning System (GPS), a satellite-based radio navigation system using multiple satellites. By triangulation of signals from three of them, an on-board receiver can pinpoint the aircraft's current position. GPS accuracy has been significantly improved by the introduction of the Wide Area Augmentation System (WAAS), with a margin of error of only a few meters, both horizontally and vertically. WAAS provides  
10 ILS-like precision approaches to airports that do not have ILS (Instrument Landing System). Also, WAAS provides information on the status of the GPS system, notifying a pilot in the event that the GPS system becomes unreliable temporarily.

## SUMMARY OF THE INVENTION

The present invention is directed to an aircraft pilot assistance system and method that  
15 detects an unsafe altitude and a dangerous nose-up or nose-down condition of the aircraft, and provides appropriate voice warnings and directions to help the pilot overcome the problem or problems detected, even if the pilot remains spatially disoriented, fatigued, or otherwise at less than his or her usual flying ability.

The present invention continuously reads the aircraft's altitude, roll rate, and nose-  
20 high or nose-low position, and combines these readings to initiate appropriate voice messages to assist the pilot to recover the aircraft to a safe condition. The altitude determination comes from a GPS/WAAS feed to a receiver connected to a computer on-

board the aircraft. The nose-high or nose-low condition is determined from GPS signals and from on-board solid state gyros. The roll rate determination is derived from GPS signals and from the solid state gyros and a turn coordinator gyro on the aircraft.

5 In the event of both an excessive altitude excursion and an excessive roll rate of the aircraft, the system initiates voice messages to the pilot's stereo headset to assist him or her to take the proper corrective action, depending on whether a nose-low or a nose-high condition has been detected. Voice messages pertaining to wing-leveling preferably are sent only to the earpiece on the side of the headset that corresponds to the low-wing side of the aircraft.

10 The present invention also responds to a partial failure of the aircraft's instrument panel to initiate a series of voice instructions which assist the pilot to perform "timed turns" routine for aircraft safety.

A general object of this invention is to provide a novel and advantageous system and method for assisting a pilot to restore the aircraft from an unsafe condition to a safe  
15 attitude and altitude appropriate to the terrain over which the aircraft is flying .

Further objects and advantages of this invention will be apparent from the following detailed description of a presently preferred embodiment thereof, with reference to the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 Figure 1 is a block diagram showing the major inputs in the present system and method;

Figure 2 is a flow chart detailing the main features of the correlation algorithm for the present system and method for critical attitude recovery of an aircraft; and

Figure 3 is a similar flow chart pertaining to a partial failure of one or more vacuum powered instruments on the aircraft's instrument panel.

## 5 DETAILED DESCRIPTION OF THE INVENTION

Before explaining the present invention in detail it is to be understood that the invention is not limited in its application to the particular arrangement shown and described since the invention is capable of other embodiments. Also, the terminology used herein is for the purpose of description and not of limitation.

10 As indicated in Fig. 1, the aircraft 10 carries:

- a GPS/WAAS-enabled radio receiver R having a GPS receiver card for receiving GPS signals giving the aircraft's altitude, forward speed and magnetic heading;

- a vacuum pressure sensor or transducer 11 which senses a failure in the vacuum system that powers the instrument panel readings on which the pilot relies to know the

15 attitude, heading, and other vital information;

- solid state gyros 12 and a turn coordinator gyro 13 which monitor the aircraft's roll rate;

- a flight recorder FR which records every 15 seconds on a hard disk the flight path of the aircraft with its heading, speed, location and altitude;

20 and a microprocessor-based computer 15 for collating and processing the information supplied to it from the receiver R, the vacuum pressure sensor 11, gyros 12

and 13, and other sources, as explained hereinafter. This computer runs an expert system algorithm, as explained hereinafter.

Stored in the computer 15 is an MSA/approach database 14 which provides information regarding the approaches being flown by the aircraft, the minimum descent  
5 altitude, decision altitude, and minimum safe altitude for airways and sectors, taking into account the terrain over which the plane is flying and obstacles on the ground along the flight path that determine the minimum safe altitude. This database is interfaced with the remainder of the system to provide warnings of an unsafe altitude. Within three miles of an airport this feature automatically de-activates to enable the landing approach to be  
10 performed without false alarms being triggered.

Computer 15 receives, from a GPS feed 16, GPS/WAAS navigation signals which tell the instantaneous air speed of the aircraft, its altitude, and its magnetic heading to initiate voice warnings and recovery instructions to the pilot. A large delta in the aircraft's altitude, an excursion to an unsafe altitude, a large delta in the aircraft's heading, an  
15 increase or decrease in airspeed, or a combination of two or more of these factors will trigger a scoring system programmed in the computer 15 to indicate an unusual attitude and will instantly analyze this unusual attitude to initiate recovery voice instructions to the pilot. To this end, the computer 15 has an audio output connected to the pilot's stereo headset to deliver voice messages to one or both of the pilot's ears, depending upon the  
20 particular warning signal the computer has just received from the GPS feed and the gyros.

In accordance with the minimum safe altitude warning, the present system monitors the current altitude via the GPS feed and compares that to the MSA for the region being flown over. This feature is disabled when the plane arrives within 3 miles of an airport, to enable the approach to be flown without false alarms being triggered.

5 In accordance with the approach monitoring capability, the present system monitors the aircraft's height above the Minimum Descent Altitude (MDA) or Decision Altitude (DA) and provides voice warnings to the pilot in hundreds of feet, and then in tens of feet, as the aircraft approaches the DA. Additionally, for a non-precision approach this system monitors the distance from the aircraft to the Missed Approach Point (MAP) and  
10 warns of reaching the MAP.

Figure 2 is a flow chart which details the main features of the correlation algorithm which the computer 15 runs. In box 21, inputs from the aircraft's turn coordinator gyro 13 and its solid state gyros 12 and the GPS feed 16 are correlated to calculate the aircraft's roll rate, or rate of turn, which indicates the stability of flight. The computed  
15 roll rate is constantly monitored to a tolerance of 3 degrees per second, and if the roll rate is within this tolerance (box 24) no corrective action is suggested.

In box 22, altitude data are obtained from the GPS feed 16. If no excessive altitude excursion is in progress (box 25) then no alert is indicated. For example, an altitude change greater than 500 feet per minute may be treated as excessive. Conversely, if an  
20 excessive altitude excursion is detected in combination with an excessive roll rate, a spatial disorientation event is judged to be in progress.

In box 23, attitude data is derived from both the GPS feed 16 and the solid state gyros  
12.

In box 26, a nose-high/nose-low determination is made by use of the attitude data (box  
23) and the altitude direction of change (box 25). If a nose-low condition of the aircraft is  
5 determined (box 26), the pilot receives appropriate voice notifications and instructions  
from the computer 15 to assist him or her to restore the aircraft to safe attitude and  
altitude. Box 27 instructs the pilot (in both ears) to reduce the engine power. Box 28  
instructs the pilot (in one ear only) to level the wings, giving voice information to the  
pilot's ear (left or right) corresponding to the low wing, and then monitors the wings level  
10 and gives a voice prompt to the pilot when wings level is achieved. Once the wings are  
leveled, box 29 instructs the pilot by voice (in both ears) to gently raise the aircraft's nose  
and add power until a positive climb is established and the aircraft is back at the  
minimum safe altitude for the area it is flying over.

Conversely, if a nose-high condition of the aircraft is determined (box 26), the pilot  
15 receives appropriate voice notifications from computer 15 to recover the aircraft from this  
condition. Box 30 instructs the pilot (in both ears) to increase the engine power. Box 31  
instructs the pilot (in both ears) to gently lower the nose of the aircraft and add power  
until a level attitude is established and the aircraft is back at the minimum safe altitude  
for the area. Box 32 instructs the pilot (in one ear) to level the wings, speaking into the  
20 ear (left or right) corresponding to the low wing, and then monitors the wings level and  
gives a voice prompt to the pilot when wings level is achieved.

In box C, the turn coordinator gyro 13 is compared to the solid state gyros 12, and in the event of a significant discrepancy between them (due to an error in the turn coordinator gyro) block 33 announces this to the pilot and instructs him or her to turn off the aircraft's automatic pilot. Such a failure of the turn coordinator gyro, while rare, does  
5 occur on occasion and when it does the present system responds in a way to avoid danger to the aircraft.

Another aspect of the present system relates to warning the pilot of a partial failure of the aircraft's instrument panel, with the accompanying loss of the heading and attitude indicators, and directing the pilot in the demanding technique of "timed turns" to respond  
10 to this problem.

For this purpose the present system includes a vacuum sensor switch 11 (Fig. 3) operatively connected to the vacuum line to detect a partial failure of one or more vacuum powered instrument panel units (typically, the directional gyro and/or the artificial horizon or attitude indicator). The vacuum sensor triggers a response by  
15 computer 15 to cause the GPS signals to be automatically timed to give an approximation of the aircraft's turn rate (block 21 in Fig. 3). If the roll rate determined from the timed GPS signals becomes excessive (i.e., past the 2 minute turn standard) a voice warning to this effect is delivered to the pilot (block 34) and the pilot is given instructions (block 35) for getting the aircraft into a standard turn rate, for notifying the pilot when the standard  
20 turn rate is established, and for notifying the pilot when the aircraft passes through the eight cardinal headings.



From the foregoing it will be evident that the system and method of the present invention constitutes an effective and advantageous way of assisting a pilot to recover from a variety of situations that can endanger the aircraft and those on board.